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ED 013 528 EF 000 027

URBAN EDUCATION SYSTEMS ANALYSIS.
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REPORT NUMBER NCES-TN-24 PUB DATE 20 JAN 67
EDRS PRICE MF-$0.25 HC-$0.64 16P.

DESCRIPTORS- *COSTS, *DECISION MAKING, DEMOGRAPHY, *SYSTEMS ANALYSIS, *URBAN EDUCATION, ESTIMATED COSTS, SCHOOL DEMOGRAPHY, USOE

ANALYSIS OF URBAN EDUCATIONAL SYSTEMS MAY BE ACHIEVED BY USE OF AN ANALYTICAL MODEL. THE MODEL MAY BE USED IN DECISION-MAKING REGARDING SCHOOL LOCATION, ENROLLMENT, FACILITIES, ORGANIZATION, PROGRAMS AND COSTS. KNOWN DATA SUCH AS MONIES AVAILABLE, STAFF ALLOCATION, AND CURRENT SCHOOL PLANT ARE INTRODUCED INTO THE MODEL. IN THE STRUCTURE OF THE MODEL--(1) AN INITIAL INVESTMENT POLICY (BUILDING) IS PROPOSED BY THE ADMINISTRATOR. THE PROPOSAL IS RELATED TO (2) AN URBAN SUBMODEL WHICH COMBINES PUPIL POPULATION, LOCATION,TRANSPOR TRANSPORTATION NEEDS, AND SOCIO-ECONOMIC CHARACTERISTICS OF THE COMMUNITY, (3) SCHOOL SUBMODEL WHICH DESCRIBES THE SCHOOL PROGRAM, SITE SPECIFICATIONS AND DEVELOPMENT PLANS, STAFF SPECIFICATIONS, AND SPACE AND EQUIPMENT PROVISIONS PER PUPIL BY INSTRUCTIONAL AREA, AND (4) COST SUBMODEL WHICH HELPS TO ESTIMATE ACCURATELY TOTAL PER PUPIL EXPENDITURE FOR REMODELING EXISTING FACILITIES COMPARED TO NEW SITE AND CONSTRUCTION PROPOSALS, PER PUPIL TRANSPORTATION EXPENDITURES, AND CURRENT OPERATION COSTS. IN AN INTERACTION SUBMODEL (5), SUBMODELS (2), (3), AND (4) ARE SUMMED. SUBMODEL (6) EVALUATES BENEFITS AND COSTS PER PUPIL IN RELATION TO EDUCATIONAL OBJECTIVES, CAUSING EXAMINATION SUBMODEL (7), THROUGH FEEDBACK, TO ALTER THE ORIGINAL PROPOSAL (1), JUSTIFYING, MODIFYING, OR ELIMINATING THE INITIAL INVESTMENT POLICY. (BD)

ED013528

Working Paper
Does Not Reflect
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EF 000027

NATIONAL CENTER FOR EDUCATIONAL STATISTICS
Division of Operations Analysis

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Technical Note
Number 24

January 20, 1967

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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Introduction

The goal of this study is to develop a dynamic "analytical model of an educational system within an urban area." The model can be utilized to evaluate alternative decisions such as: school location, school enrollment size, school facilities, grade spans and school programs by examining their relationships. These data could provide guidance on major educational policy decisions, such as the concentration of educational facilities within urban regions, which is the educational park concept.

The economic choice of school location, size of school, and extent of facilities and programs to be developed within an urban area depend on many dynamic factors that must be assessed and projected to the planned implementation time frame. This entails the assessment of the characteristics, location and mobility of the potential pupil population, the assessment of the public transportation network and the impact of these factors on the adequacy of the facilities provided and the resulting quality of education received. There are factors of social and political importance that must be considered and there are budgetary constraints on the choice of alternatives.

Problems of this scope, in which many quantitative and qualitative factors are present and in which future requirements are planned, cannot usually be resolved by intuition and judgment alone. The educational planner's decision process can be considerably enhanced by a methodology in which alternatives may be quantified by effectiveness and cost measures.

A basic concept of the study is that of an urbanized area, and not the more commonly used concept of the Standard Metropolitan Statistical Area, which is defined by county borders which often extend out into rural areas. A simple definition of an urbanized area is one which contains at least one city of 50,000 inhabitants or more as well as the surrounding closely settled region.

The eleven largest urbanized areas range from the Greater New York Area down to the Baltimore Area, and these account for almost a quarter of the total school population.

Where schools shall be located, how large they shall be, what organizational decisions must be made as to the grouping of schools within these plants, the selection of staff and facilities for the schools, and finally the pupil assignment policy--these are the kinds of decisions either specified beforehand, or determined by the model.

The realities, or given conditions within which the model will have to operate are such things as where the children live and the kinds of families they come from, the economic resources and the budgetary constraints of the school districts within the urbanized area, the existing transportation network and its accompanying costs, such geographical factors as the terrain and land use, as well as its value, and finally the means used for projecting ahead in time the anticipated conditions as far as they can be estimated at the time the schools will actually be in operation.

In order to see the relationships among all these factors, and to fit them into a pattern that would reflect the realities of the decision-making process of an urban school area, a basic model logic has been developed (see Figure 1). The logic of the model operates as follows: initial decisions (Box 1) which can be based on such factors as the monies available, acceptance of current school plant location, organizational patterns as to staffing, class size, etc., are stated. These will have to be stated in quantitative terms and will be fed into a set of three sub-models: urban (Box 2), school (Box 3), and cost (Box 4). The urban sub-model (Box 2) will contain those characteristics of an urbanized area which economically, demographically, geographically, and sociologically describe the urbanized area. The essential demographic characteristics as to the location and characteristics both of school children and their families would be included.

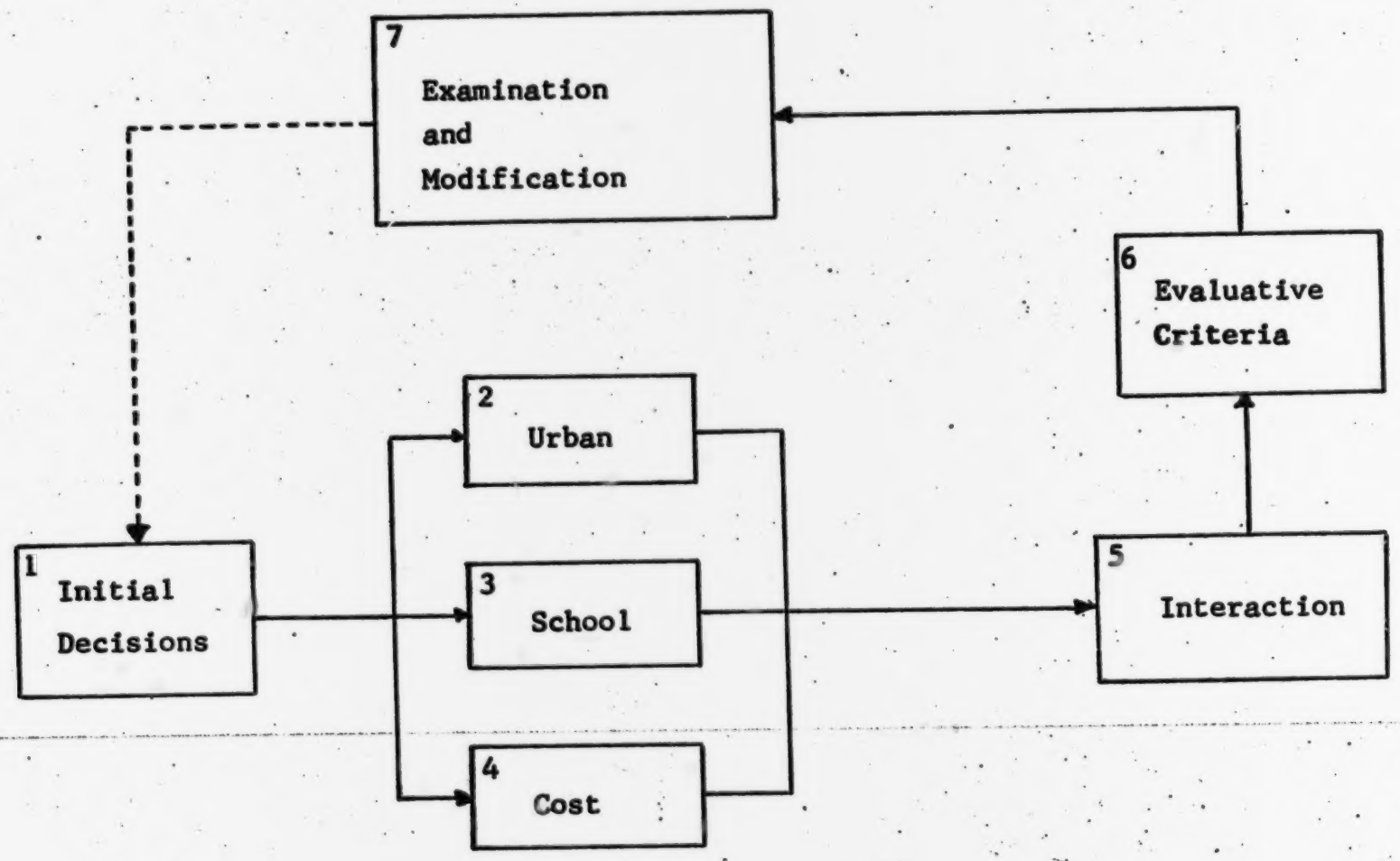
The school sub-model (Box 3) would contain the necessary data which would express how the schools operate with respect to where the school plants are located, how they are staffed, and what present attendance boundaries are.

Finally, the cost sub-model (Box 4) will incorporate the necessary cost information which accompanies both the urban and school sub-models. For example, the location of a school within an urbanized area would necessitate having in the cost sub-model the means of evaluating such factors as transportation costs of pupils getting to school and the acquisition of land.

The initial decisions decided upon in Box 1 are then "fed through" the three sub-models: urban, school, and cost; and these in turn are all fed into the box labeled Interaction. The Interaction sub-model (Box 5) will contain the relationships between the three sub-models and will produce, for any given set of initial decisions, the resulting "evaluative criteria" (Box 6).

The evaluative criteria are the consequences, or the educational program resulting as "output" from the "input" of the initial decisions.

Suppose, for example, that the question of integration is crucial in an urbanized area wishing to utilize this urban education systems analysis basic model. Quantitatively, this might be measured in terms of percent non-white and, to be realistic, it might be well to have some measure of socio-economic class. As an initial decision, the present operating pattern of a district could be inserted and run through the urban, school, and cost sub-models and as a result the extent of percent non-white and socio-economic class for each school would be shown as one of the evaluative factors. The educational decision makers, be they superintendent, staff, or board members, could then examine these "consequences" and perhaps wish to modify them. They might wish to specify a more even pattern of distribution of minority groups among schools, and by so stating these new conditions as <u>new</u> initial decisions these could then be fed back into the model, run through, and the consequences in terms of cost, personnel, building utilization, and the like, would then be shown as a new set of evaluative factors.



URBAN EDUCATION SYSTEMS ANALYSIS

Basic Model

Figure 1

The basic model will be kept as flexible as possible so that a wide variety of crucial factors can be inserted either as initial decisions or be made available as evaluative criteria. To take another example: suppose there were no initial decisions as to school boundaries but a certain degree of integration was specified, the basic model would then be able to indicate where school boundaries would need to be set in order to achieve that degree of integration. Considerable effort is being made to incorporate, realistically, those economic, social and geographic factors which may bear significantly upon the operation of schools.

DEVELOPMENT OF THE URBAN SUB-MODEL

The approach presently contemplated for developing the urban sub-model is to systematically examine all the pertinent socio-economic characteristics of each small section of an urbanized area--such as census tracts--to delineate areas around each school building that will meet stated criteria, such as the degree of integration. This process of coalescing smaller units into larger groups, known technically as "hierarchical grouping," may require a computer, as large amounts of data must be examined systematically. The resulting school boundaries would then assure that each school's pupil composition would meet any desired criteria, or show what factors make it impossible. This technique of "hierarchical grouping" can be utilized with any units, such as blocks, census tracts, or school attendance areas; so long as there is sufficient data describing the socio-economic characteristics of those in each area.

DEVELOPMENT OF THE SCHOOL SUB-MODEL

The detailing of the manner in which the sub-models are being constructed has progressed in most detail with respect to the school sub-model.

School Requirements

In this part of the decision-making procedure the description or specification of the school plant and staff will be made for each school attendance area. A large part of this definition is to be provided by local policy, at least initially, for part of the decision-making procedure is to examine the effect of that policy on the adequacy of the school facilities provided. Where standards or legislation requiring certain facilities is not operable, guidelines on acceptable plant space determination and staffing patterns may be developed on a statistical basis by examining the space and staff allocation of operating school systems. Here we would be tacitly assuming the adequacy of that allocation and its applicability to the proposed school plant.

School Plant Specification

The primary purpose of the school plant specification is to identify the extent of facilities to be provided at some appropriate level of aggregation so that the adequacy of those facilities may be assessed and so that the resource implications of those decisions may be reasonably accurately estimated. One would also like data to be readily accessible so that the functional specification of space and resources may be made.

In new plant construction a common measure employed defining the amount of space to be provided is floor area. In the employment of this decision-making procedure it is necessary for the educational planner to specify (the measure employed would be on an area/pupil basis) available space in three categories:

1. Classroom area--classrooms, shops, laboratories, home-making, industrial arts, and other academic units.

2. Auxiliary area--library, music rooms, administration, cafeteria, gymnasium and auditorium.

3. Service and Structure Area--corridors, general and custodial service, toilet rooms, stairways, boiler rooms and mechanical equipment.

Available data will be utilized wherever possible, but in some instances approximations will have to be made--or at least until the relationship of factors can be established so that more accurate estimates can be made. It is believed that in many instances there will be found to be little or no relationship between some factors which means, in effect, that they can then be left out of them all.

There is statistical data available on space allocation which may either be incorporated directly into the model or used as a guideline for a policy input by the educational planner. For example, the Educational Facilities Laboratory, New York City, found the following distribution of space allocation in secondary schools (sample of 100) built during the period of 1956 to 1958:

Room or Facility	Area Provided Per Pupil (sq.ft./pupil) Low	Median	High
Library	2.0	3.0	4.0
Music	1.5	2.5	3.5
Administration	2.0	3.0	4.0
Cafeteria & Kitchen	4.0	5.5	7.0
Gymnasium & Lockers	10.0	15.0	23.0
Auditorium & Stage	2.0	5.5	8.0

As part of that same survey, space allocation was seen to vary as a function of the region in which the construction took place:

Region	Median Areas Per Pupil (sq.ft.) Classroom	Auxiliary	Service	Total*
Northeast	34	39	38	116
Southeast	27	24	15	75
North Central	38	37	45	117
South Central	26	31	38	78
Western	35	32	24	95

(* Median of total area figures)

This variation no doubt is an expression of local policy and/or architectural consideration of regional environment and climatic conditions. It indicates that space allocation must be considered at these regional levels or lower.

The result of this part of the school plant specification then will be:

Category	Area Per Pupil
Classroom Area	---
Auxiliary Area	---
Service and Structure Area	---
Total Area	---

Standards or guidelines are available on the acreage of the school site required by grade level. As indicated above these may be used in the initial specification of policy as direct requirements or they may be established as above on a statistical basis. The National Conference on Schoolhouse Construction (1964 edition) recommends the following minimum site sizes:

School	Site Size
Elementary	10 acres + 1 acre/100 pupils
Junior	20 acres + 1 acre/100 pupils
Senior	30 acres + 1 acre/100 pupils

where pupils are measured by maximum projected enrollment.

At this point in the procedure the total interior and exterior area requirement of the school plant will be specified.

Staffing Specification

A convenient measure of input into the staffing pattern of the school are the number of teachers and/or professional personnel. Much of the guidelines on staffing patterns indicate that staffing is independent of enrollment size. For example "Profiles of Excellence" by the National Educational Association indicates that superior schools will have at least 65 professional personnel per 1000 pupils of which at least 15 are non-classroom teachers. The relationship of staffing requirements as a function of enrollment size will have to be investigated. Some data (School Management Jan. 1966) on the school district level aggregation level indicates variation in staffing patterns with school district size. Based on data for fiscal year 1965-66 the following national staffing patterns were reported as a function of increasing school district size:

STAFF	DISTRICT SIZE (Students)	STAFF/1000 SPU (Staffing Pupil Unit) (SPU = (1 ELEM. + 1.1 SECOND) student)
Administrators	1. (25,000 plus)	.27
	2. (12,001-25,000)	.30
	3. (6,001-12,000)	.41
	4. (4,001-6,000)	.53
Classroom Teachers	1. "	39.54
	2. "	40.45
	3. "	41.50
	4. "	42.25
Operation Personnel	1. "	6.02
	2. "	5.78
	3. "	5.66
	4. "	5.30

Similar type of data should be considered on the school attendance area level of aggregation.

The output of this part of the procedure will be the number of staffing personnel as a function of enrollment size. The following staffing categories will be considered:

1. Administration
2. Instruction
3. Health
4. Operation
5. Maintenance

Both professional and nonprofessional staff will be included.

Cost Determination

The cost determination of a particular educational policy alternative is one of the evaluation factors to be considered in this decision-making procedure. Some of the elements of this cost determination are:

1. the construction of new school plants
2. the renovation and expansion of existing facilities
3. special equipment and staff cost
4. land acquisition cost
5. current operating expenses of school systems
6. transportation costs

The educational alternative resource implications will be measured relative to these categories.

Construction of New Facilities

The level of aggregation commonly used in new building construction cost estimation is dollars per area of school floor space. It is anticipated that this level of aggregation will be used in this model. It is necessary to separate out, however, those cost categories which are not directly related to the building structure (including permanently fixed equipment such as plumbing, heating and electrical). A logicai breakout with definitions of cost categories for new building construction is contained in Bureau of Budget Form No. 51-R507. The principal cost categories used in that form are:

1. Contract cost--The contract cost for the construction of schools means the actual (not estimated) cost of construction as shown in the contract between the local educational agency and general contractors. Included are costs of permanently fixed equipment and costs for plumbing, heating, and electrical work. Not included are costs of movable school furniture and equipment.

2. Legal, administrative costs--includes legal fees and administration cost in connection with preparation of contract documents.

3. Architect, engineering fees--includes cost for professional architectural and engineering services performed in connection with the construction project.

4. Furniture, equipment costs--means the amounts spent for such items as pupils' desks, tables, chairs, teachers' desks, cabinets, shop equipment, and similar items which are normally included in furnishing and equipping new school buildings.

5. On-site improvement costs--includes the amount spent for grading, draining, seeding, planting and preparing site for use after the building has been constructed. It does not include the cost of site acquisition.

Data is available for several years on the dollar expenditure reported against these categories. Cost functions relating contract cost and total floor area of building will be investigated, i.e.

If these functions do not yield sufficient precision it may be necessary to develop multivariate functions of cost, where floor area is identified by the specific facility, i.e. auditorium, gymnasium, classroom and cafeteria. Other breakouts by region and type of material may also be necessary to improve precision.

The remaining cost expenditures may be proportional to the contract cost, e.g., architectural fee of 6% of contract cost. This will be examined.

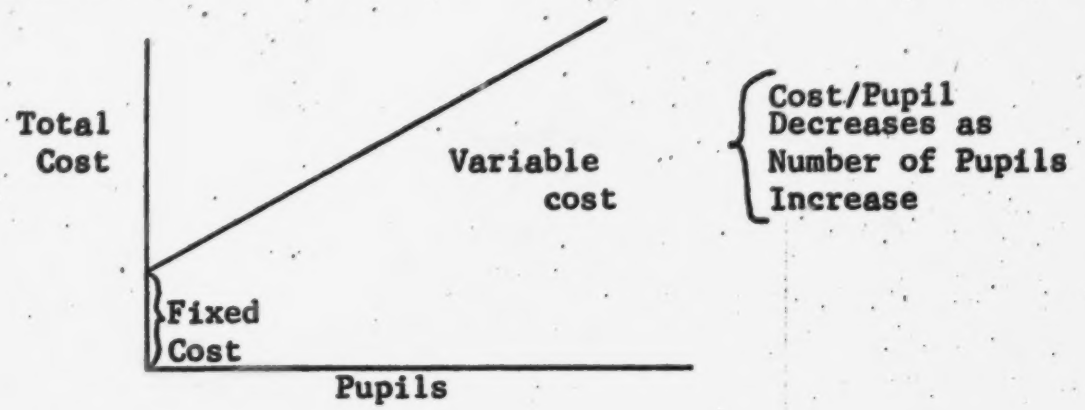
Expansion and Renovation of Facilities

In the investigation of the consolidation of existing school districts one of the policy decisions available to the educational planner is the renovation and/or expansion of the school facilities contained within the consolidated region. The renovation cost would seem to be primarily influenced by labor and equipment cost and related to the age and condition of the present building. Statistical data will have to be investigated to

develop these relationships. The cost of expansion may be approximated by new building cost in lieu of direct data, or through the use of data available on the cost per classroom.

Special Equipment and Staff Cost

Much of the economy to be achieved through large school attendance areas is due to large special purpose staffs and equipment in which a basic cost or fixed charge is incurred and unit cost (cost/pupil) is lowered as the number of pupils increase. Examples might be computing machinery, language laboratories,



diagnostic (health) centers and library equipment. This type of equipment should be specified and costed independent of the "normal" equipment defined in the new construction section.

Land Acquisition Cost

A policy alternative to build new or to use existing facilities will affect the cost structure in terms of land value. The net dollar value between the cost of newly required land area and reclaimed land value must be determined. There may be, for example, a favorable trade on a cost basis of central city land for suburban land. These exchange values will be investigated.

Current Operating Expenses

The major portion of the cost of current operating expenditures is staff salaries. In the school year 65-66 salary expenditures accounted for approximately 85% of the net current expenditures (School Management Jan 66) in school districts of over 25,000 students. Salary schedules by regions will be applied against the staffing patterns developed in the school requirements section.

Other current operating cost categories are non-salary administrative, instructional, health, operation and maintenance expenditure. Expenditures for such items as teaching materials, and utilities are believed to be a function of enrollment and/or plant size. These cost functions will be investigated and developed.

Transportation Cost

For large (some specified area and/or time of travel) school attendance areas it will become necessary to provide transportation for students. This cost will be a function of the location and density of students with respect to a given school site. The basic cost element in this determination will be the cost/student/distance due to the type of transportation provided. It might be possible to assume this is constant for certain ranges of school attendance areas and types of transportation.

Total Cost

The total cost associated with a particular policy alternative will consist of the expenditures relative to the above categories.

Examination of Evaluative Criteria

There are many measures one may examine as a result of this procedure to choose among educational resource allocation proposals. In the long run one would of course desire to maximize a measure of the educational benefits resulting from a given cost expenditure. This assumes one has the measuring instruments on the benefits accruing from the use of equipment (e.g. laboratories), the benefits accruing from a given student-teacher ratio, the effect of diagnostic centers on retention rates and so forth. It is anticipated that in the long term this type of measurement will be made when more research is undertaken in these areas (and concomitantly) when more extensive data become available.

In the short term the measures to be examined as a basis for evaluation of resource allocation proposals will be the operational indices that are direct outputs of this procedure. One assumes that the educational planner has developed weights (implicitly or explicitly) for these operational indices and based on this experience and judgment will select among the proposals. Some of the operational indices to be examined are:

1. Racial and socio-economic composition of the realigned school attendance areas.

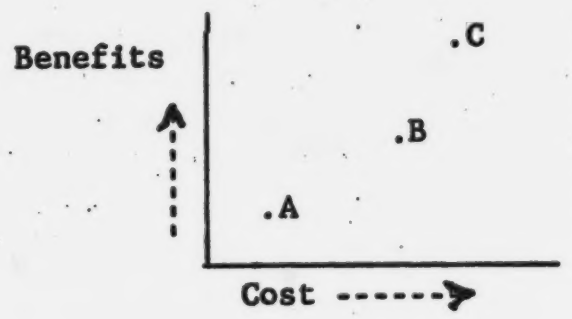
2. Budget statement of investment cost (of new or renovated school plants) and annual operating cost.

3. Utilization rates of school facilities (pupils per cafeteria, pupils per diagnostic center).

4. Student transportation data (average traveling distance).

These measures are commonly quoted and are now used extensively as a basis for educational resource allocation determination.

Formally the planner is concerned with choosing among alternatives say A, B, C based on the relative benefits versus cost implications of each alternative. For example:



if the benefit measure represents some weighted value of the operational indices and the cost measure represents the total estimated cost over the planning period then the educational planner is concerned with the tradeoff decisions of cost and benefits as well as the constraints on resource sources. These efficiency factors as well as the many political and social factors not considered in this quantitative approach must be considered in the final evaluation process.

FUTURE DEVELOPMENT

So far, the basic model logic of the Urban Education Systems Analysis as it has been described is "static", that is to say reflects the educational situation in a given urbanized area at a given time. The next step will be to develop a "dynamic" model, one that will incorporate the past experience and configuration of both the schools and the community and be able to project ahead in time what the future conditions would be like under various assumptions. This more sophisticated model would then have produced evaluative factors that would show what would be the situation in future years as a consequence of the initial decisions specified.